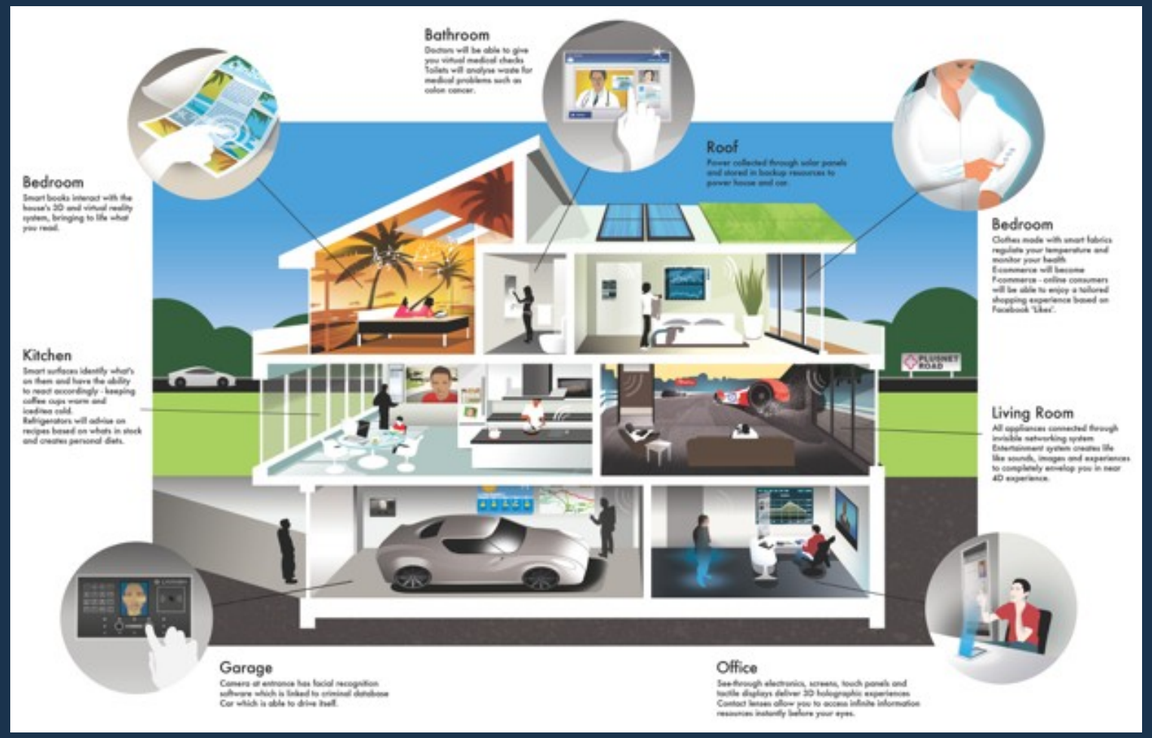
Home multimedia and automation systems with GStreamer

Jan Schmidt @thaytan www.centricular.com

Embedded Linux Conference Europe
October 30 2019 | Lyon | France

Centricular

Home Automation

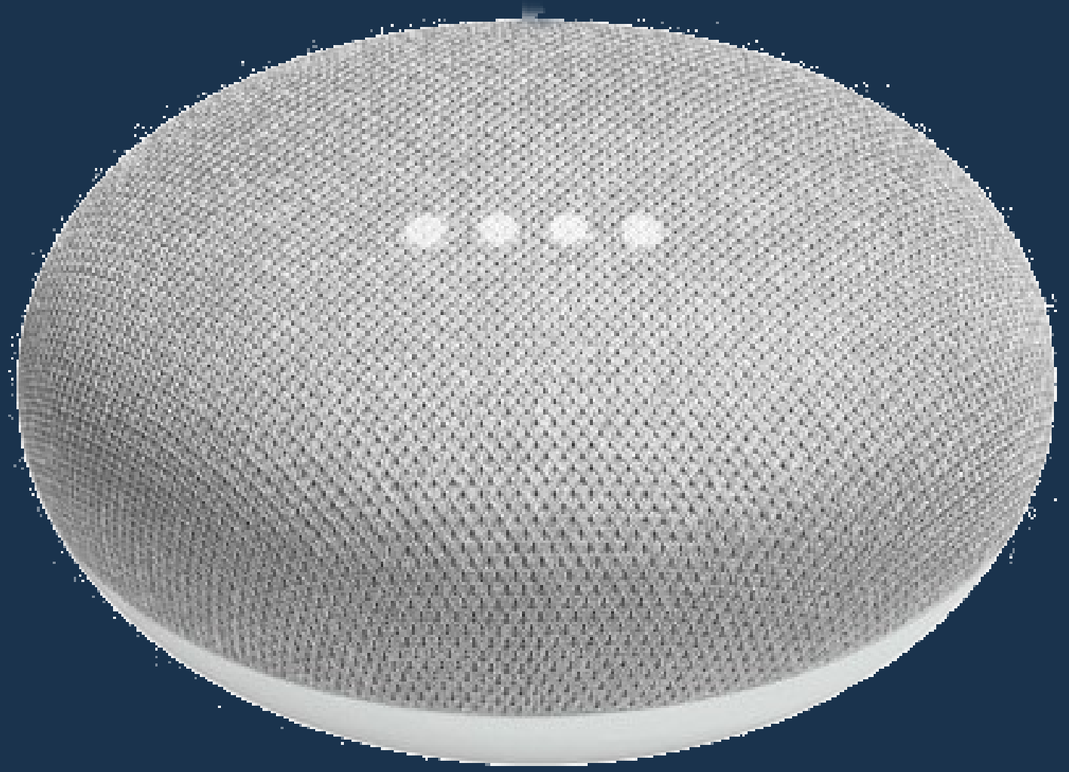


- Voice Control
- Remote control / clever appliances
- Context aware

https://www.flickr.com/photos/99781513@N04/15182533048

Smart Assistants

- Commercial Offerings
  - Google Home
  - Amazon Echo
  - Apple HomePod
- Lots of integrations
- Everything is a closed silo
- And cloud based!



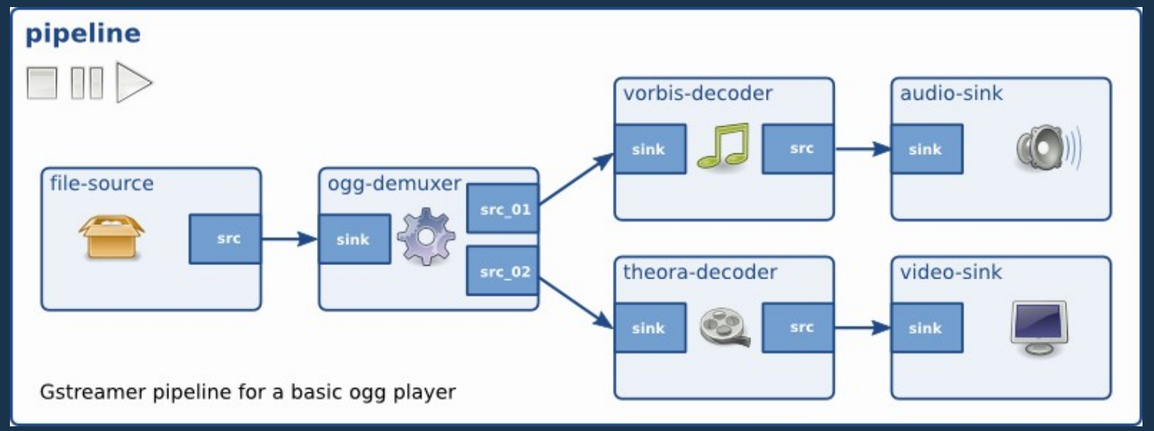
Free Software!

- **Mycroft**
- Mozilla DeepSpeech
- TTS – multiple options
- HomeAssistant
- MQTT
- Arduino
- Cheap SoCs
- Smart switches (Sonoff ESP8266)

Let's talk about GStreamer

GStreamer

- Media processing framework
  - Video and Audio
  - But not only those
- GStreamer = Data processing pipelines



Centricular

GStreamer: Audio Conversion

- Pipelines can:
  - Decode/encode audio codecs
  - Capture or output audio
  - Convert sample formats
  - Resample
  - Combine / separate channels
  - Do audio processing

GStreamer: Audio Streaming

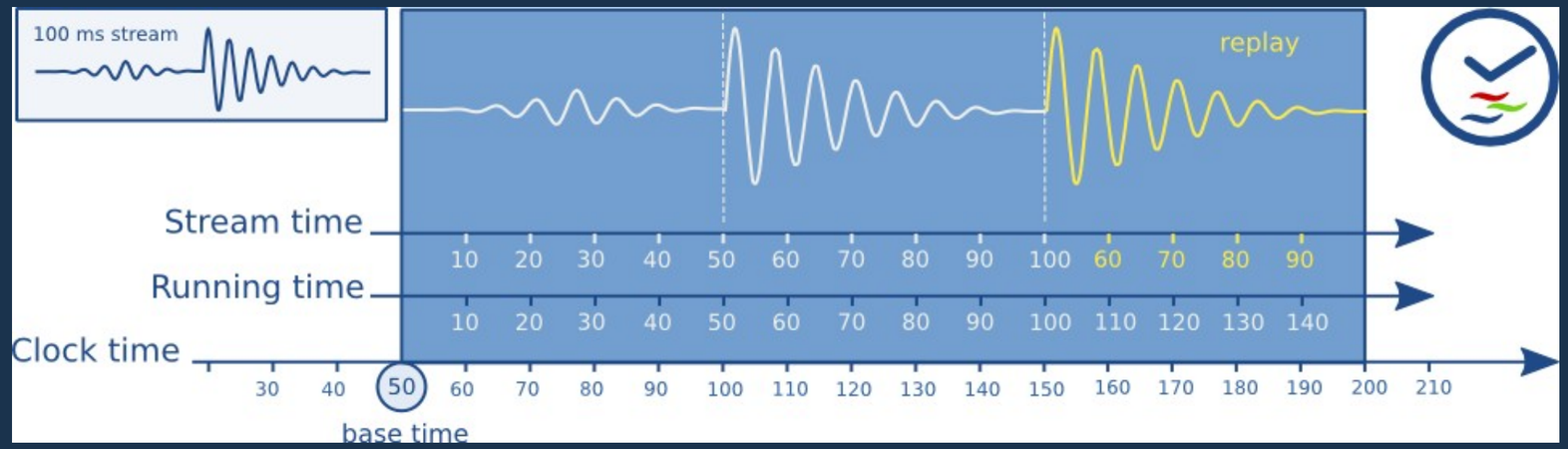
- GStreamer can also deliver media across a network
  - RTP, HTTP, RTSP, WebRTC, UDP....
- And much more...

Idea 1: Music Playback

- 2012 – I first saw a Sonos™ system
- Music in every room
- Configurable zones
- Remote control
- “This reminds me of a thing did with GStreamer”
- Multiple network connected speakers
- Enter Aurena

Synchronisation

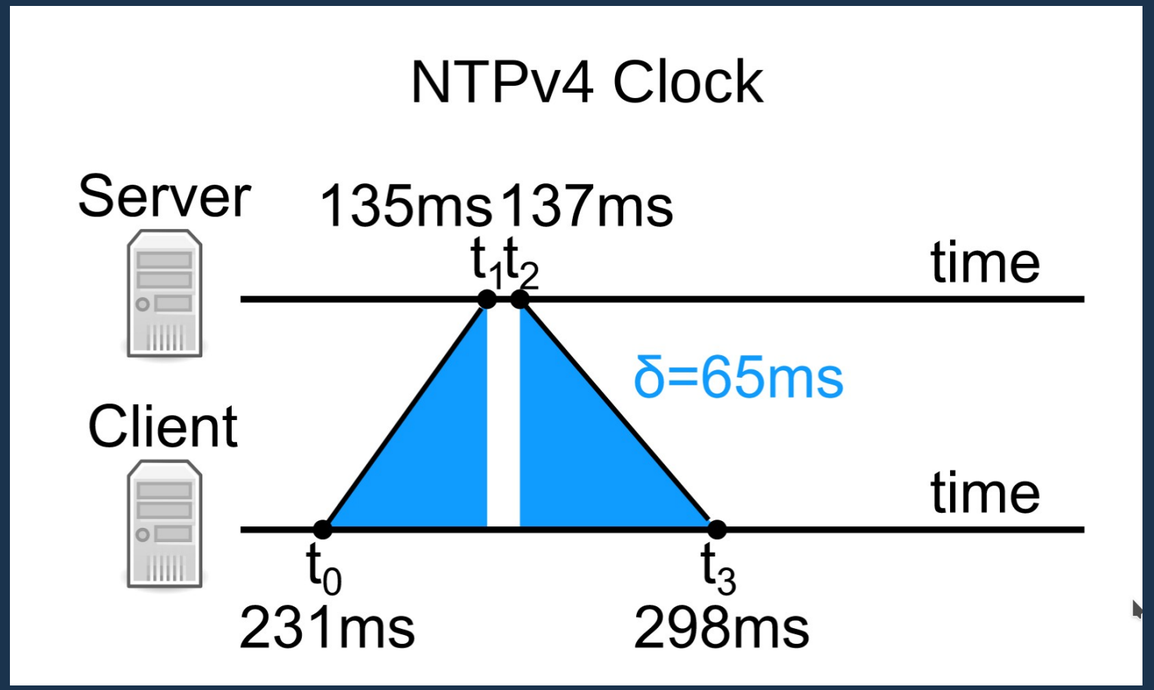
- Key Piece: Clocks and clock tracking
- The GStreamer clock system is complicated
- Problem: Every clock runs at a different rate



Centricular

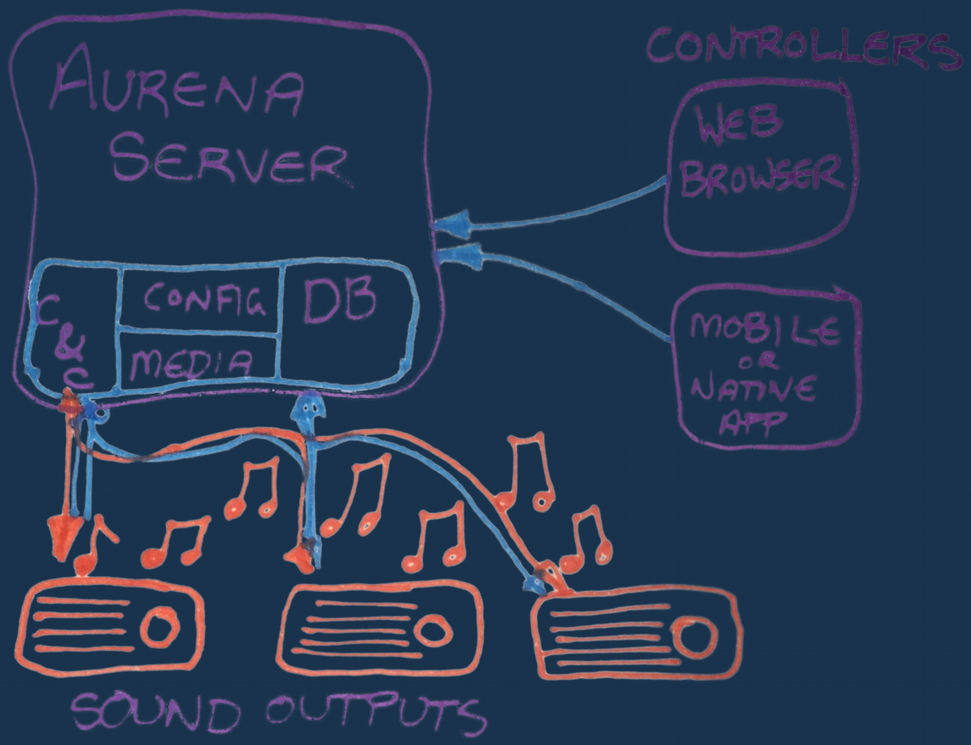
Synchronising Clocks

- Transfer clocks across the network
- GStreamer Net Clock Provider
  - Custom protocol. Since 2005
- NTPv4
  - Since 1.6 in 2015
- PTP IEEE1588:2008
  - Since 1.6 in 2015



Aurena Architecture

- Control server daemon
- Clients for output
- Clients sync to the server clock
- Clients get control commands



Demo

Aurena

- Video
- Multi-channel / Surround mapping
- Zone support

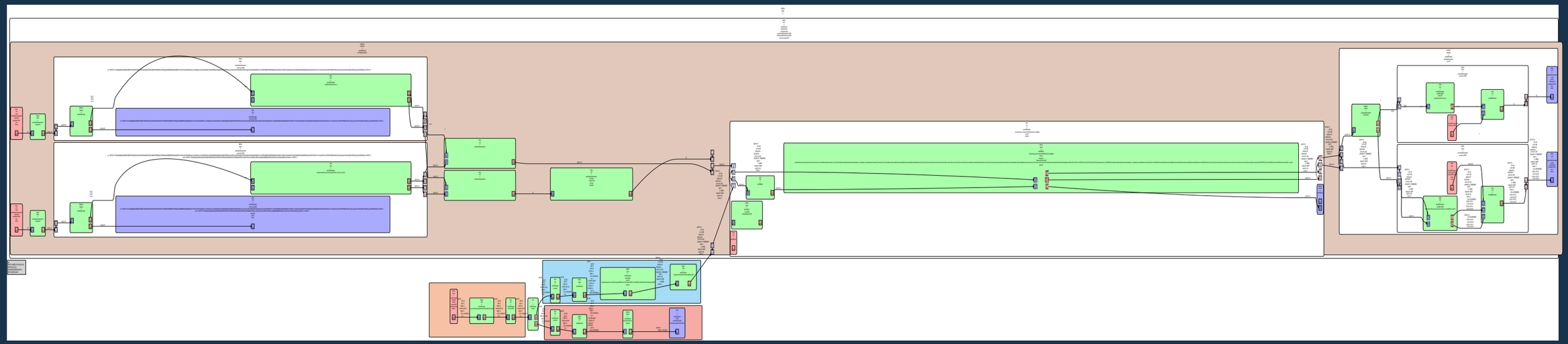
Home Automation: Cameras

- Security / monitoring
- Doorbells
- Context awareness

- Raspberry Pi – rpicamsrc
- RTSP
- Motion Detection

Home Automation: Cameras

GStreamer WebRTC Pipeline

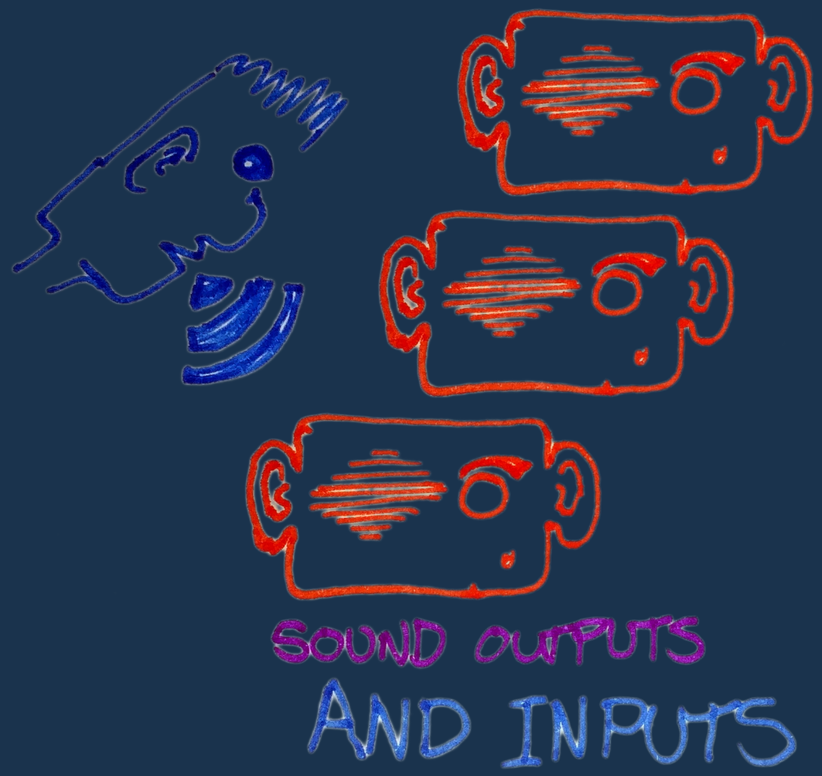


Home Automation

What about Voice Control?

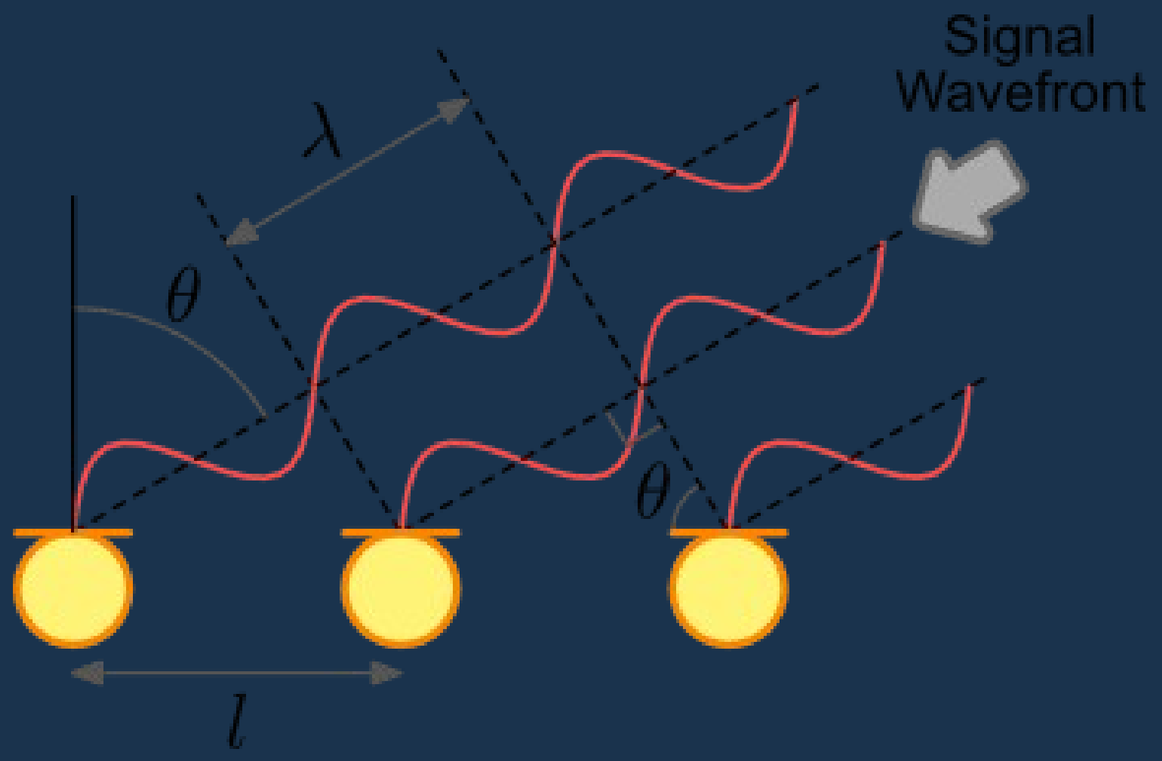
Secret Plan

- Aurena + Microphones = Senders
- Network clock synched
- Central Receiver
- Audio processing



Microphone Arrays

- Detect audio arrival directions
- Distinguish audio sources
- Vary by:
  - Array shapes
  - Number of microphones



1st Attempt 2015

- Android Devices
- Stream microphones to server
- ManyEars for triangulation

- ManyEars:
  - Real-time microphone array processing
  - Robot audition
  - 8 microphones in a fixed grid
  - Localisation, tracking, source separation

The Speed Of Sound

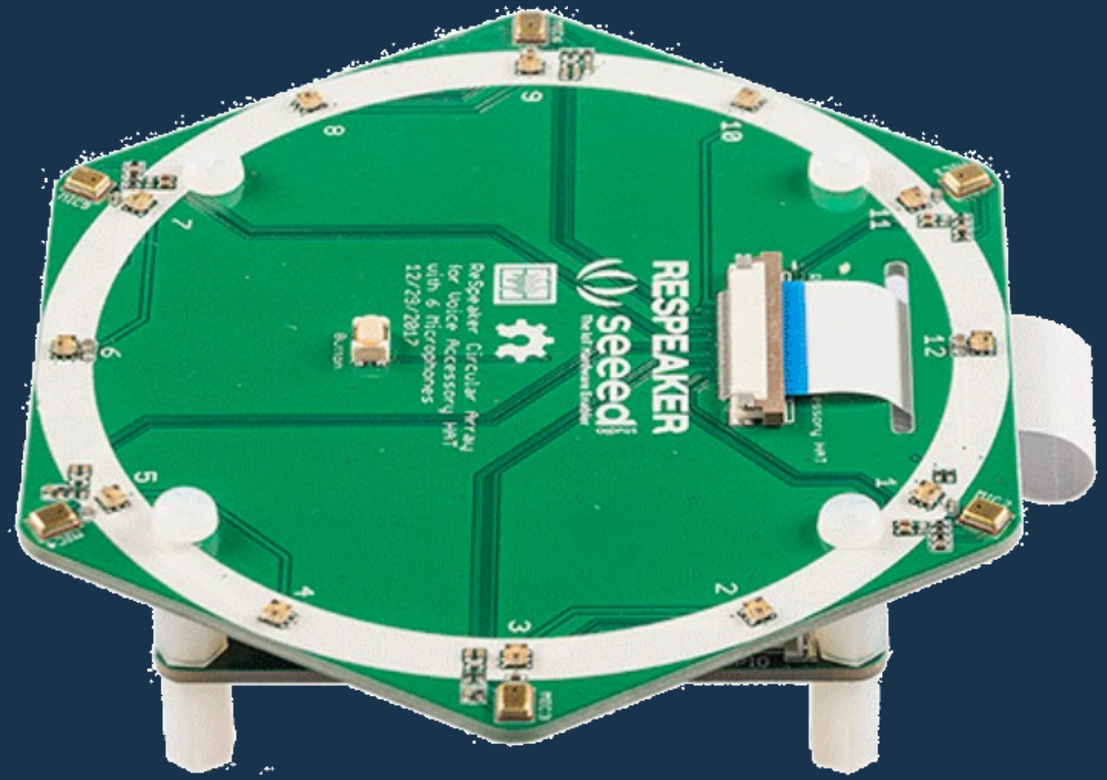
- C_{air} = (331.3 + 0.606 * Tc) m/s
- ~343 m/s @ Tc = 20C
- 1 ms = ~34.3 cm @ 20C
- Timing Inaccuracy = Spatial Inaccuracy

Results

- Abject Failure
- Problem: The Android audio subsystem.
- Up to 100ms uncertainty in sample timing.

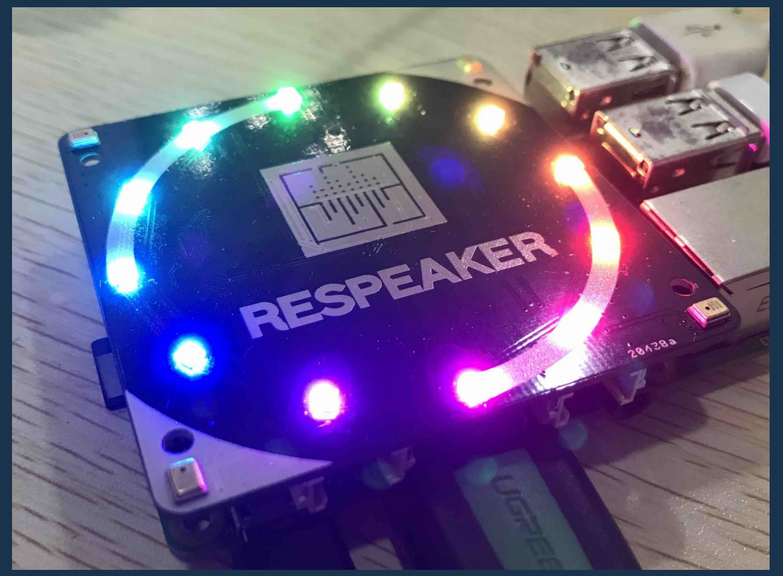
2nd Attempt 2018

- Microphone array hardware everywhere
- All the voice assistants have them

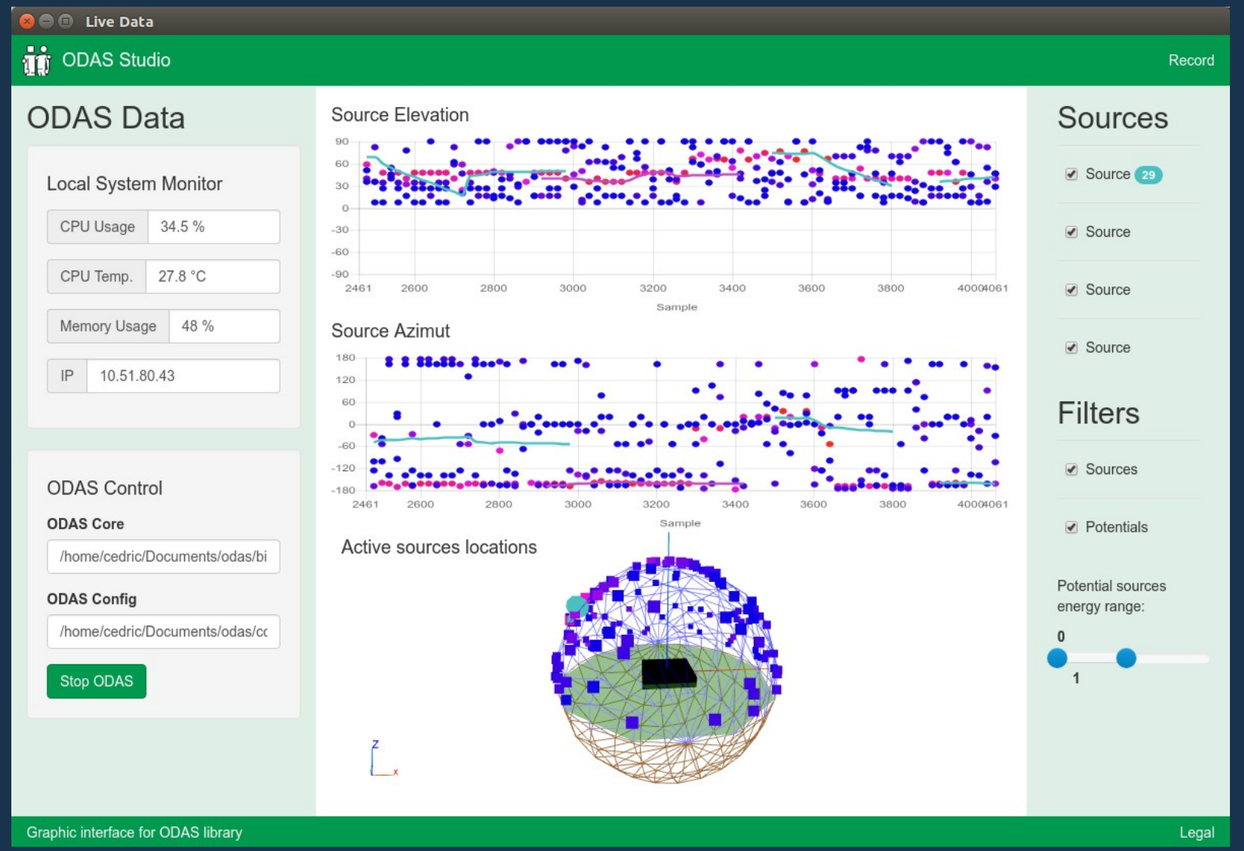


Hardware Options

- Seeedstudio Respeaker
- Respeaker Core – 6 mic array
- Raspberry Pi hats – 4 mic array, 2 mic array



ODAS



Centricular

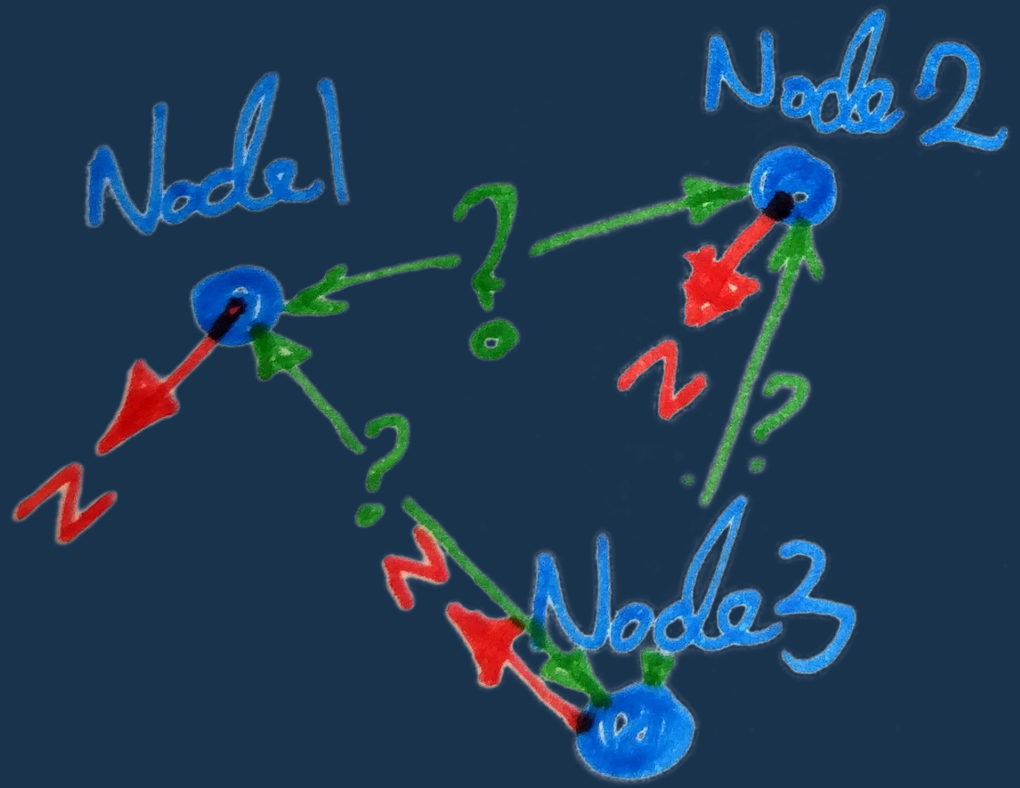
Distributed Microphone Arrays

- Per node arrival direction
- Per microphone arrival time + audio
- Per node sound source separation
- A node can't tell source distance (far-field effect)

Demo

Calibration

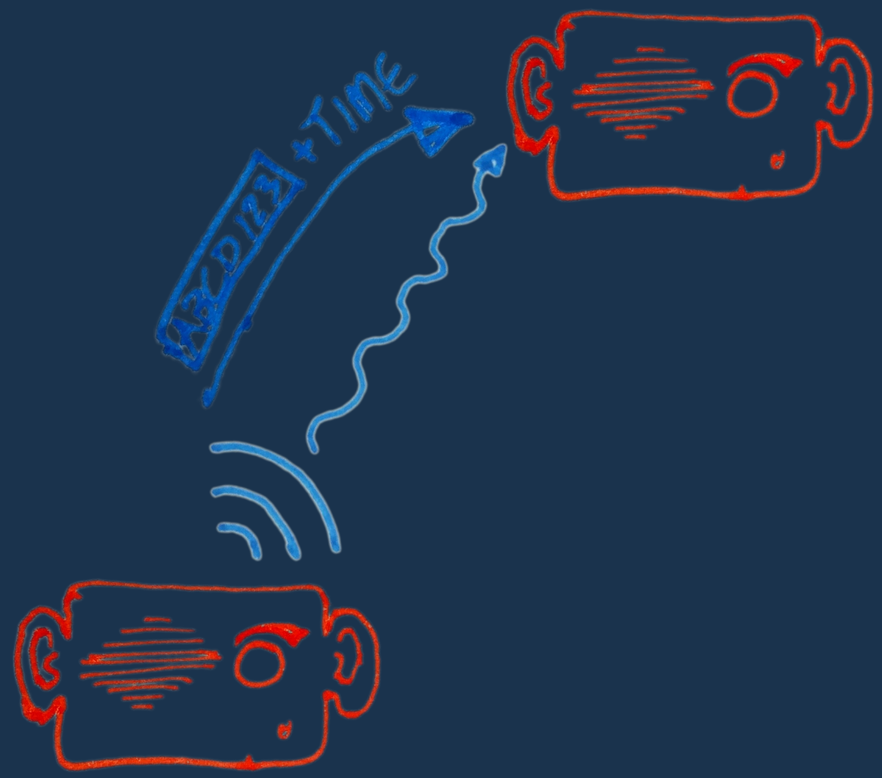
- Unknown Configuration
- Can't triangulate from that



Calibration

- Play sounds
- Listen
- Extract DOA, delay and identity
- Solve for relative positions

343m/s * (Arrival time - Send time) = DISTANCE



Problems

- How to send information?
- What sound volume to use? Don't want to deafen people

Calibration So Far

- libquiet MODEM
- Packet structure
- Different modulations
- Current problems:
  - Precise timing recovery
  - Problems beyond ~0.5m transmission

Demo

Music

- http://freemusicarchive.org/music/Pierce_Murphy/This_Isnt_Magic_It_Is_Just_Music/
  - CC-BY-4.0
- http://freemusicarchive.org/music/Dee_Yan-Key/Seven_Old-Style_Pieces/06--Dee_Yan-Key-Handel
  - CC-BY-NC-SA-4.0
- http://freemusicarchive.org/music/Aitua/Elements/ - CC-BY-NC-SA-4.0
- http://freemusicarchive.org/music/Peter_Rudenko/15_Etudes/ - CC-BY-4.0

Random Links

- https://github.com/thaytan/aurena/
- https://github.com/introlab/odas_web
- Localization of RW-UAVs Using Particle Filtering Over Distributed Microphone Arrays
  - https://introlab.3it.usherbrooke.ca/mediawiki-introlab/images/b/b9/Lauzon2017localization.pdf
- "ACOUSTIC SOURCE LOCALIZATION IN HOME ENVIRONMENTS - THE EFFECT OF MICROPHONE ARRAY GEOMETRY" - 2017
  - https://pdfs.semanticscholar.org/9eff/83e75e38bfe35d01bd0e5ecba87300fc3571.pdf